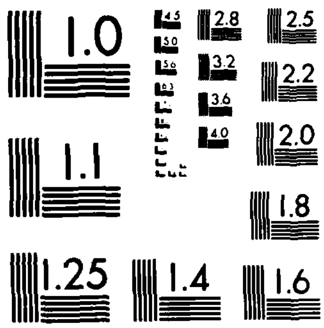
AD-A149 308 IMAGE PROCESSING INSTRUMENTATION FOR SPECKLE INTERFEROMETRY AND IMAGING(U) GEORGIA STATE UNIV ATLANTA DEPT OF PHYSICS AND ASTRONOMY H A MCALISTER 1/1

UNCLASSIFIED 07 NOV 84 AFOSR-TR-84-1172 AFOSR-83-0257 F/G 17/8 NL

END


1.0
4.5
5.0
5.6
6.3
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

AFOSR-TR- 84-1172

14

FINAL TECHNICAL REPORT

to the

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

for the interval

1 Aug 83 - 30 Sep 84

Grant AFOSR-83-0257

AD-A149 308

IMAGE PROCESSING INSTRUMENTATION FOR SPECKLE INTERFEROMETRY AND IMAGING

Harold A. McAlister
Principal Investigator

Department of Physics and Astronomy
Georgia State University
Atlanta, Georgia 30303
(404) 658-2932

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S): AFOSR-TR- [illegible] 1172
6a. NAME OF PERFORMING ORGANIZATION: Georgia State University; 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION: Air Force Office of Scientific Research
6c. ADDRESS (City, State and ZIP Code): Department of Physics and Astronomy, Atlanta, Georgia 30303	7b. ADDRESS (City, State and ZIP Code): Bolling Air Force Base, DC 20332
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: AFOSR; 8b. OFFICE SYMBOL (If applicable): NP	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: AFOSR Grant 83-0257
8c. ADDRESS (City, State and ZIP Code): Bolling AFB, DC 20332	10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.
61102F	2917	A6	

11. TITLE (Include Security Classification): Image Processing Instrumentation

12. PERSONAL AUTHOR(S): Harold A. McAlister

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
Final	FROM 1 Aug 83 TO 30 Sep 84	1984 November 7	10

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This final technical report describes the rationale for the acquisition of computer hardware for assembling an interactive image processing facility to be used for on-going programs of high angular resolution speckle interferometry of astronomical objects. Speckle interferometry is a technique for obtaining diffraction limited spatial information of distant objects through the turbulent atmosphere while simultaneously permitting differentia positional measurements of very high accuracy. This method is being applied at Georgia State University in a program whose scientific goal is the detection of planetary mass companions in binary star systems. Funding from the DOD-University Research Instrumentation Program has permitted the acquisition of a dedicated digital image processing system to optimize the reduction and analysis of these data. The system components include a VAX 11/750 computer serving as host machine to an International Imaging Systems Model 70/F image processor with a variety of peripherals. The system is fully operational and extensive software development is underway.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☒ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION: Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE NUMBER (Include Area Code); 22c. OFFICE SYMBOL

DD FORM 1473, 83 APR   EDITION OF 1 JAN 73 IS OBSOLETE.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

IMAGE PROCESSING INSTRUMENTATION

FOR

SPECKLE INTERFEROMETRY AND IMAGING

RESEARCH OBJECTIVES

The principle scientific objective to be carried out under AFOSR Grant 83-0257 was to secure under the guidelines of the DOD-University Research Instrumentation Program a facility for the interactive image processing of astronomical data obtained for speckle interferometry and imaging. The capability of such instrumentation for finely tuning the reduction and analysis of data was considered to be essential for the extraction of the most accurate spatial information from speckle observations being obtained under AFOSR Grant 81-0161. These observations are directed toward the discovery of low-mass planetary companions to binary star systems through very high precision measurements of relative orbital motion on which submotions can be expected to be superimposed. The correct compensation for atmospheric seeing effects is of vital importance to the best utilization of these data, and interactive image processing provides the most efficient and most powerful approach to this problem.

The requested image processing system would also provide a totally new capability for the restoration of high resolution images which are otherwise distorted by atmospheric turbulence. This would allow us to more thoroughly carry out a survey program for asteroid duplicity in which a resolved elongated asteroid may mimic a double object. The flexibility of image display in an image processing system was considered to be extremely valuable in this context as well as in the processing of speckle observations of faint

extragalactic objects.

In summary, this research project sought to establish at Georgia State University a first rate digital image processing system which would provide us the best possible means for processing high spatial resolution observations being obtained under ongoing AFOSR support.

RESEARCH ACCOMPLISHMENTS

Following the awarding of AFOSR Grant 83-0257 to Georgia State University in the summer of 1983, a careful reassessment of the originally requested equipment items was made. As originally outlined in our proposal, an existing Perkin-Elmer 3220 computer was to be upgraded by memory, disk and tape expansion and interfaced to new image processing hardware which, along with terminals, a color video display unit and several hardcopy output devices, would constitute the image processing facility. The disadvantages of this approach were that the PE 3220 would not be dedicated to image processing since it serves as a general departmental computing facility and that the system would be non-standard in terms of image processing systems found at major astronomical observatories. The first drawback led to the possibility of timesharing delays in writing back and forth from the image processor to the host computer, while the second disadvantage meant that the extensive arsenal of image processing software under development at the national observatories would not be easily adaptable to our system. Reacting to these considerations we investigated the possibility of acquiring a Digital Equipment Corporation VAX 11/750 computer to serve as the dedicated host to the image processing system. The VAX interfaced to an International Imaging Systems Model 70/F image processor would define a system identical to those at

Kitt Peak National Observatory and the National Radio Astronomy Observatory. Much to our surprise and delight, we found that a complete VAX 11/750 system could be purchased at a price comparable to that required to upgrade the existing Perkin-Elmer computer while simultaneously giving us a factor of four increase in core memory and disk space. Thus permission was sought from the AFOSR to reprogram the grant funds. Following the receipt of AFOSR approval, the items detailed in Table 1 were ordered. Delivery of all the hardware items in Table 1 was completed in early spring 1984.

With the decision to purchase a new host computer rather than upgrade an existing one, it became obvious that a full-time systems manager was needed to oversee the facility. This person would be of critical importance to implementing the image processing software and to the ultimate accomplishment of our scientific goals. The Dean of the College of Arts and Sciences readily agreed to providing 100% support from college funds for this position, and in May 1984, Dr. Paul C. Schmidtke joined us as imaging processing systems manager. Dr. Schmidtke had formerly been employed at Kitt Peak National Observatory as a scientific programmer and brought extensive image processing skills to our program.

During the summer of 1984, our efforts were primarily aimed at bringing the VAX up to routine operation under the VMS operating system and to interfacing the VAX and I^2S image processing system. By early fall, the complete system and its peripheral hardware were fully operational and the facility was then available for the specific research goals outlined previously.

At the present time we are engaged in adapting software previously written for the Perkin-Elmer computer to the VAX/I^2S environment and in writing new software for image restoration. Examples of the output of

TABLE 1. EQUIPMENT PURCHASED UNDER AFOSR GRANT 83-0257

Digital Equipment Corporation	
Computer System Package consisting of:	
VAX 11/750 CPU with 2 MB memory and floating point accelerator	
RUA81 Disk Drive with controller	
TU 80 Tape Drive with controller	
DZ 11 8-line Serial Multiplexer	
LA 120 Hard Copy Console	
Total Package Price	76,871.50
2 VT 220 and 2 VT 240 Terminals	4,895.65
DR 11W General Purpose Digital Interface	1,883.00
International Imaging Systems, Inc.	
Image Processor Package consisting of:	
Model 70/F4 Image Processor	
4 512x512x8 bit Refresh Memory Channels	
8 512x512x1 bit Graphics Overlay Channels	
Trackball Programmable Cursor	
Videometer	
Feedback ALU to the 16-bit Accumulator	
12-bit in, 16-bit out Input Function	
Video Digitizer	
Mitsubishi C-3910 RGB Monitor	
System 570 Software Package	
Model 7008-S Host Computer Interface	
Total Package Price	57,525.00
Macrolink, Inc.	
512 KB Memory Expansion for PE 3220 Computer	3,255.00
Digital Television Imagery, Inc.	
DTI-20 Video Integrator	15,500.00
Matrix Instruments, Inc.	
Model 3000 Color Graphics Recorder and misc. Camera Backs	13,465.70
Advanced Color Technology, Inc.	
ACT-1 Color Ink Jet Printer and Video Interface	8,760.00
Total Equipment Cost	182,155.85
Total Charged to Grant AFOSR 83-0257	175,035.00
Cost Sharing from Other Sources	7,120.85

the analysis program for binary star speckle data are shown in Figures 1 and 2. These figures have been generated using the ACT 1 ink jet plotter obtained under this grant. Figure 1 shows the display generated by the image processing system in conjunction with the running of a program called PLOTR. On the left half of the display is the two-dimensional vector-autocorrelogram of the binary star ADS 8804 in which intensity levels have been color-contoured. This binary star system, which is being routinely observed as a part of the AFOSR supported extra-solar planet search program, has an angular separation of approximately 0.5 arcsecond. On the right half of the display is a series of radial profiles passing from the center of the autocorrelogram through the binary star peak, in the case of the middle profile, and at 10° increments clockwise and counterclockwise from this peak. Figure 2 shows a similar display after a correction for the broad Gaussian-shaped background induced by atmospheric seeing has been eliminated through a boxcar smoothing and subtracting algorithm. Two dimensional centroiding algorithms then give the cartesian coordinates of the binary star peak in the autocorrelogram with sub-milliarcsecond repeatibility. We are experimenting with several background correction algorithms. A particularly promising approach appears to be the subtraction of the low frequency peak in the power spectrum arising from the broad background in the autocorrelogram followed by subsequent Fourier transforming back to the spatial domain.

Experiments with image reconstruction algorithms are also currently underway. These experiments have employed, so far, only simulated data used in developing a "shift-and-add" approach of R.H.T. Bates and F.C. Cady to recovering relative intensities from speckle data. We anticipate developing software appropriate to the "speckle masking" method developed by G. Weigelt

at the University of Erlangen-Nurnberg as well as for the phaseless image reconstruction method of J. Fienup. Following the interfacing of our video digitizer and integrator to the image processing system in early 1985, we will be able to apply these methods to carefully calibrated data for real astronomical objects.

Although the major thrust of the effort expended during the tenure of this grant award has related to the numerous systems related tasks, the significant gains in analysis capability for the newly acquired system have already been demonstrated. This system will be invaluable in the research programs carried out under separate AFOSR funding.

NEW INVENTIONS OR PATENTS

No new inventions or patents resulted from this research effort.

PROFESSIONAL PERSONNEL

The following personnel contributed to this researh program. No salaries have been charged to AFOSR Grant 83-0257.

Harold A. McAlister - Principal Investigator - Associate Professor, Georgia State University

Paul C. Schmidtke - Image Processing System Manager, Georgia State University

William I. Hartkopf - Senior Research Associate, Georgia State University

Donald J. Hutter - Research Associate, Georgia State University

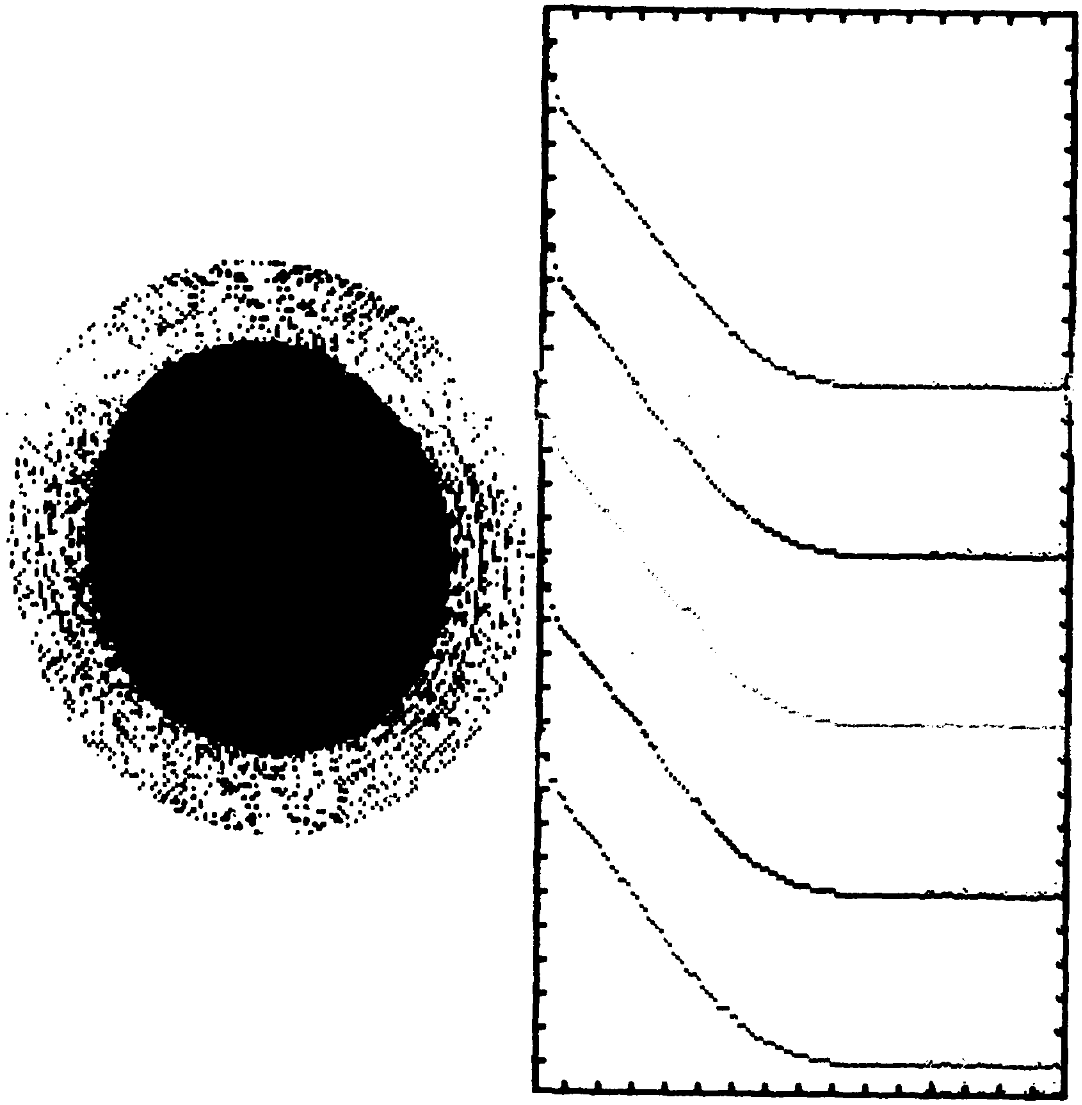


FIGURE 1 - The integrated vectorautocorrelogram of a sequence of speckle frames of the 0.5 arcsecond separation binary star system ADS 8804 is shown at left. Color contours indicate intensity levels. The binary star peaks can be seen in the outer green contour along a line shifted approximately 10 degrees from the vertical. Radial profiles passing throuugh this peak (the central green profile) and at 15 degree shifts clockwise and counterclockwise are shown at right.

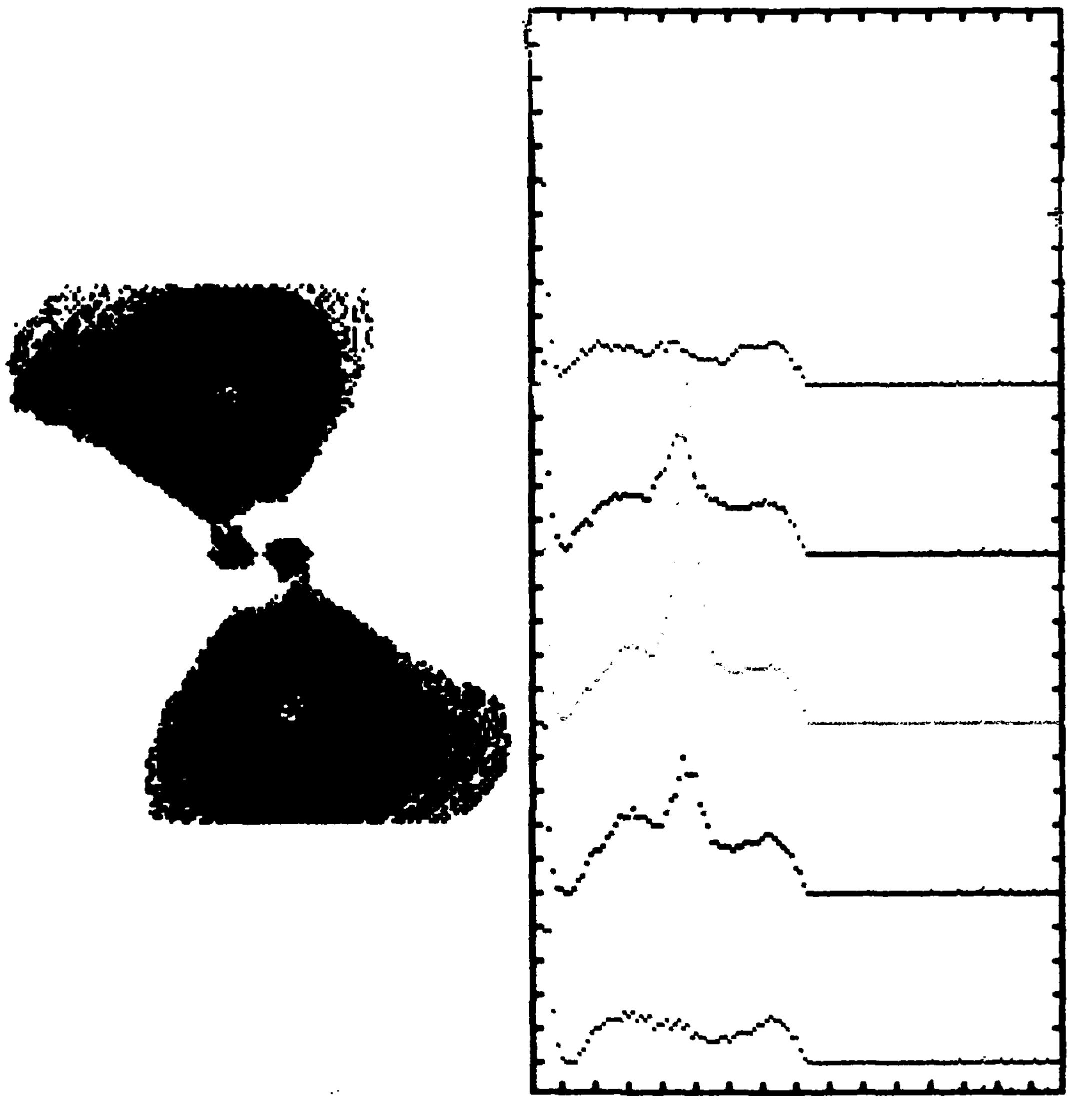


FIGURE 2 - Following subtraction of the broad Gaussian-like background of the vectorautocorrelogram, the binary star peaks are significantly enhanced in the seeing-corrected display at left. At right, the radial profile through one of the peaks is clearly enhanced for precise centroiding.

END

FILMED

2-85

DTIC